<u>CLAIMS</u>

I claim:

*Sub A67*

1.  An apparatus for performing beamforming on a
plurality of signals in a reception channel received from a
5   receiving antenna array, said signals including simultaneous
data signals from a plurality of transmitters, said circuit
comprising:

an Nx1 switched beam beamforming circuit for weighting
and combining outputs of N antenna receiving elements and
10  generating a single beam therefrom based on a beam scheduling
sequence, wherein N is an integer greater than 1;

a beam schedule generating circuit for generating said
beam scheduling sequence for switching between ones of a
plurality of beams for generation by said beamforming circuit;

15  a frequency downconverting circuit for converting said
beam signal to baseband; and

a multi-path/multi-user estimation circuit for generating
path estimates and path estimate errors for each of said
multiple simultaneous transmitters from said baseband beam
20  signal.


2.  The apparatus of claim 1 further comprising an
analog-to-digital converter between said frequency
downconverting circuit and said multi-path/multi-user

estimation circuit and wherein said multi-path/multi-user
estimation circuit comprises a digital signal processor.

3.    The apparatus of claim 2 wherein said beam schedule
generating circuit is adapted to generate said beam scheduling
sequence by determining a minimum mean square error estimation
of a state-space model of said reception channel.

4.    The apparatus of claim 3 wherein said beam schedule
generating circuit switches said selected beam at a rate
faster than a data rate of said signals in said reception
channel.

5.    The apparatus of claim 3 wherein said apparatus is
adapted to receive spread spectrum signals, said spread
spectrum signals having a chip rate, and wherein said control
circuit switches said selected beam at said chip rate.

6.    The apparatus of claim 5 wherein said spread
spectrum signals are code division multiple access signals.

7.    The apparatus of claim 6 wherein said code division
multiple access signals are direct sequence-code division
multiple access signals.

8.    The apparatus of claim 4 wherein said beam schedule generating circuit revises said beam scheduling sequence at predetermined intervals, said beam schedule generating circuit controlling said beamforming circuit in accordance with

5    repetitions of a given beam scheduling sequence until revised.

9.    The apparatus of claim 8 further comprising a memory and wherein said beam schedule generating circuit stores each beam scheduling sequence in said memory and retrieves said beam scheduling sequence from said memory to be used for

10   controlling said beamforming circuit during said interval of its use.

10.    The apparatus of claim 4 wherein said beam schedule generating circuit generates said beam scheduling sequence by solving:

15    $$\hat{f}_k = \bar{\hat{f}}_k, \text{ for } k = 0,1, \ldots, G - 1$$

$$\hat{F}_{G-1} = \underset{F_{g-1}}{\arg\max} \; Tr\{JP_{G-1|G-1}(F_{G-1})\}$$        .

11.    The apparatus of claim 10 wherein $P_{G-1|G-1}(F_{G-1})$ is determined by running a Kalman filter.

12.    The apparatus of claim 11 wherein $P_{G-1|G-1}(F_{G-1})$ is

20    determined by:

$$P_{k|k-1}(F_{k-1}) = A_k P_{k-1|k-1}(F_{k-1}) A_k^H + Q$$

$$S_{k|k-1}(F_k) = f_k^H A(\phi) P_{k|k-1}(F_{k-1}) A^H(\phi) f_k + f_k R f_k^H$$

$$P_{k|k}(F_k) = P_{k|k-1}(F_{k-1}) \left[ I - f_k A^H(\phi) S_{k|k-1}^{-1}(F_k) f_k^H(\phi) P_{k|k-1}(F_{k-1}) \right].$$

13. A method for performing beamforming on a plurality of signals in a reception channel received from a receiving antenna array, said signals including simultaneous data signals from a plurality of transmitters, said method comprising the steps of:

(1) weighting and combining outputs of N antenna receiving elements and generating a single beam therefrom based on a beam scheduling sequence, wherein N is an integer greater than 1;

(2) generating said beam scheduling sequence for switching between ones of a plurality of beams for generation by said beamforming circuit;

(3) converting said beam signal to baseband; and

(4) generating path estimates and path estimate errors for each of said multiple simultaneous transmitters from said baseband beam signal.

14.    The method of claim 13 further comprising the step

of converting said beam signal from analog to digital between

steps (3) and (4).

15.    The method of claim 14 wherein step (2) comprises

5    generating said beam scheduling sequence by determining a

minimum mean square error estimation of a state-space model of

said reception channel.

16.    The method of claim 15 wherein step (2) comprises

switching said selected beam at a rate faster than a data rate

10    of said signals in said reception channel.

17.    The method of claim 15 wherein said signals in said

reception channel are spread spectrum signals, said spread

spectrum signals having a chip rate, and wherein step (2)

comprises switching said selected beam at said chip rate.

15    18.    The method of claim 17 wherein said spread spectrum

signals are code division multiple access signals.

19.    The method of claim 18 wherein said code division

multiple access signals are direct sequence-code division

multiple access signals.

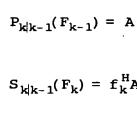20    20.    The method of claim 16 wherein step (2) comprises

(2.1) revising said beam scheduling sequence at predetermined intervals; and

(2.2) using each given beam scheduling sequence repetitively said until beam scheduling sequence is revised.

21. The method of claim 20 further comprising the steps of:

(5) storing each beam scheduling sequence in a memory; and

(6) retrieving said beam scheduling sequence from said memory to be used for controlling said beamforming circuit during said interval of its use.

22. The method of claim 16 wherein step (2) comprises generating said beam scheduling sequence by solving:

$$\hat{f}_k = \hat{\bar{f}}_k, \text{ for } k = 0,1,\ldots, G - 1$$

$$\hat{F}_{G-1} = \underset{F_g - 1}{\arg\max} \ Tr\{JP_{G-1|G-1}(F_{G-1})\} \quad .$$

23. The method of claim 22 wherein step (2) further comprises determining $P_{G-1|G-1}(F_{G-1})$ by running a Kalman filter.

24. The method of claim 23 wherein step (2) comprises determining $P_{G-1|G-1}(F_{G-1})$ by:

$$P_{k|k-1}(F_{k-1}) = A_k P_{k-1|k-1}(F_{k-1}) A_k^H + Q$$

$$S_{k|k-1}(F_k) = f_k^H A(\phi) P_{k|k-1}(F_{k-1}) A^H(\phi) f_k + f_k R f_k^H$$

$$P_{k|k}(F_k) = P_{k|k-1}(F_{k-1}) \left[ I - f_k A^H(\phi) S_{k|k-1}^{-1}(F_k) f_k^H(\phi) P_{k|k-1}(F_{k-1}) \right] \ .$$

Add A5